PATENT ABSTRACTS OF JAPAN

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(71)Applicant : INTERNATL BUSINESS MACH CORP <IBM>

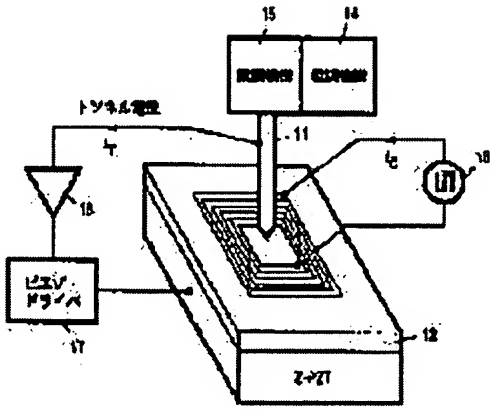
(72)Inventor : WATANUKI MASAAKI
TSUJI SATOSHI
IKEDA YOSHIHIRO

(54) RECORDING AND REPRODUCING DEVICE OF HIGH DENSITY

(57)Abstract:

PURPOSE: To improve a recording speed by recording a signal in a magnetic recording medium by a magnetic field generated from a chip according to the signal current by impressing a signal current to a coil.

CONSTITUTION: The chip 11 is formed closely to the magnetic recording medium 12, and the coil 13 is formed on the medium 12. The chip 11 is connected with a rough adjusting mechanism 14 and a fine adjusting mechanism 15 to be position-controlled. The rough adjusting mechanism 14 is a voice motor, e.g. and as the fine adjusting mechanism 15, a piezo-element, etc., are used. An X-direction and Y-direction, namely directions parallel with the surface of the magnetic recording medium, are adjusted by the fine adjusting mechanism 15 connected to the chip, and a Z-direction vertical to the surface of the magnetic recording medium adjusted by a Z pizeo-element formed at the lower part of the medium. A piezo-driver 17 is connected to the Z element. The coil 13 is constituted of a lithograph on the medium 12, and this coil 13 switches the magnetic direction of the tip of the chip.



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CLAIMS

[Claim(s)]
[Claim 1] The high-density recording device which carries out [performing signal record to the above-mentioned magnetic-recording medium by the field which generates according to this signal current from the above-mentioned chip by having the core which consists of a non-magnetic material, the chip which has the thin film which consists of the soft magnetic materials which cover this core, the magnetic-recording medium of conductivity / front face /, the coil formed in the perimeter of the above-mentioned chip, and a means impress the signal current to the above-mentioned coil and impressing the signal current to the above-mentioned coil, and] as the description.
[Claim 2] Equipment according to claim 1 further characterized by having the above-mentioned chip and a means to control the above-mentioned distance between magnetic-recording media in a high density recording apparatus according to claim 1 according to a means to generate tunnel current between the above-mentioned chip and the above-mentioned magnetic-recording medium, a means to measure the above-mentioned tunnel current, and the measurement value of the above-mentioned tunnel current.
[Claim 3] The above-mentioned coil is equipment according to claim 1 characterized by being formed of RISOGURAFU on the above-mentioned magnetic-recording medium.
[Claim 4] The core which consists of a non-magnetic material, and the chip which has the thin film which consists of the soft magnetic materials which cover this core, A means to generate tunnel current between a conductive magnetic-recording medium, and the above-mentioned chip and the above-mentioned magnetic-recording medium, The high density record regenerative apparatus characterized by having the above-mentioned chip, a means to control the above-mentioned distance between magnetic-recording media, and a means to read the magnetic-recording signal recorded on the above-mentioned magnetic-recording medium according to a means to measure the above-mentioned tunnel current, and the measurement value of the above-mentioned tunnel current.
[Claim 5] claim 1 to which the non-magnetic material which forms the above-mentioned core is characterized by consisting of either or such combination of Tungsten W, Platinum Pt, Iridium Ir, platiniridium PtIr, Gold Au, glass fiber, and a carbon fiber thru/or 4 -- equipment given in either.
[Claim 6] claim 1 characterized by for the above-mentioned soft magnetic materials which cover the above-mentioned core being NiFe, CoZrNb, or CoFeSiB, and thickness being 500-3000A thru/or 4 -- equipment given in either.
[Claim 7] claim 1 characterized by the ability to drive the above-mentioned chip by the piezo-electric element thru/or 4 -- equipment given in either.
[Claim 8] claim 2 characterized by the ability of spacing of a record-medium side and the above-mentioned chip to adjust the above-mentioned magnetic-recording medium to a record flat surface by the piezo-electric element which can be driven perpendicularly thru/or 4 -- equipment given in either.
[Claim 9] A means to read the above-mentioned magnetic-recording signal is equipment according to claim 4 characterized by being the means which used the magneto-resistive effect component.

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DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Industrial Application] This invention relates to the equipment about the magnetic recording adapting the tunnel current used for a scanning probe microscope, and playback, especially, raises the switching rate of the chip for record, and aims at improvement in a recording rate. Moreover, it makes it possible to simplify a manufacture process by the improved coil configuration.
[0002]
[Description of the Prior Art] The microscope which generally used the probe is called the scanning probe microscope, i.e., SPM (Scanning Probe Microscope) or SXM (physical quantity of front faces, such as tunnel current and force between atoms, with local X) etc. In these, applicable fields, such as surface observation of a metal, a semi-conductor, etc. and observation of the magnetic domain of the magnetic substance, have spread increasingly. In recent years, development about the high density record technique which used the scanning probe microscope (SPM) is performed briskly.
[0003] The following reference is released as a technique which applied SXM to high density magnetic recording.
[0004] (1) H.J. Mamin, P.H. Guethner, and D. Rugar, "Atomic-Emission-from a-Gold-Scanning-Tunneling-Microscope-Tip", Phys. Rev. Lett., Vol. 65, No. 19,pp.2418-2421, 5, Nov. 1990.(2) R.C. Barrett and C.F. Quate, "Charge storage in a nitride-oxide-silicon-medium by scanning capacitance microscopy" J.Appl.Phys.70(5), 1991 and pp.2725-2733. (3) R. C.Barrett and C.F.Quate, "Large-scale charge storage by scanning capacitance microscopy", and Ultramicroscopy 42-44 (1992), pp.262-267. (4) J.Moreland and P.Rice, "High-resolution tunneling-stabilized magnetic imaging and recording", APPL.Phys.Lett., 57 (3), 310, 1990, and pp.310-312. (5) O. Watanuki and S.Tsuji et al. and "Small magnetic patterns written with ascanning tunneling microscope" and IEEE Trans. Magn., Vol.27, and No.6, Nov.1991 and pp.5289-5291. (6) T. Ohkubo and J.Kishigami et al., "Submicron magnetizing and its detection based on the point magnetic recording concept", and IEEE Trans.Magn., Vol.27, No.6, 1991, pp.5286-5288. [0005] The configuration of the data-logging regenerative apparatus which used STM proposed makes a conductive chip approach a conductive magnetic-recording medium front face, the relative position of a chip and a medium is moved on condition that tunnel current regularity, the current according to data is added to the coil of the perimeter of a chip in recent years, and magnetic recording is performed to a record medium by generating a field from a chip. At the time of playback, Z location of a chip is decided according to the tunnel current which a chip is made to approach a magnetic-recording medium and is generated, and the information on a magnetic-recording medium is read according to the magneto-resistive effect (MR) effectiveness. MR sensor of the probe mold which carried out the coat of the NiFe film is examined by J.C.Slonczewski. (Reference 7)
[0006] (7) J.C.Sclonczewski, "Magnetic theory of very small devices (invited)", J.Appl.Phys.67(9).1 May 1990, pp.5341-5346. [0007] For example, it is made to approach until tunnel current generates the chip which consists of magnetic materials, such as nickel or a permalloy, to vertical recording media, such as Co-Cr, and record and playback are performed, holding this contiguity location, and a piezo-

electric element etc. is used for this position control.
[0008] Barrett and others (the above-mentioned reference 2 and 3) has attained recording density of 50 Mb/in2 using the charge trap in SiO2 constituted between P type silicon and Si3N4 (the above-mentioned reference 2 and 3). According to this approach, high density record becomes possible, but there is a fault that maintenance of data is difficult, by discharge of the charge accompanying time amount progress.
[0009] Formation of the magnetic pattern of the submicron unit by SXM is realized on the horizontal or the vertical recording medium (the above-mentioned reference 4, 5, and 6). According to these techniques, the size of a magnetic dot is 400-800nm, and this is equivalent to the recording density of number Gb/in2.
[0010] However, in these indicated techniques, it is difficult to switch the magnetization direction at the tip of a chip to high-speed reversal, i.e., a high speed. When following the approach proposed conventionally, the switching rate was the order of KHz, 200-300kHz switching is attained and the limitation performed data logging. However, it is the technique in which high-speed switching is naturally required for corresponding to improvement in the speed of data drawing speed. With the chip which carried out the coat of the nonmagnetic material with the magnetic thin film of high permeability, this invention realizes high-speed switching. About the switching rate of the chip which carried out the coat, according to the following reference (8), when a high-frequency field is impressed at the tip of a chip by the thin film head, it is observing that it can respond to the rate of 10MHz or more.
[0011] (8) K.Sueoka, K.Okuda et al., "Study of tip magnetization behavior inmagnetic force microscope", J.Vac.Sci.Technolol., B 9(2), pp.1313-1317, Mar/Apr 1991. [0012] In formation of a magnetic pattern, in order to change the magnetization direction of a chip, it is required to form a coil in the surroundings of a magnetic chip (the above-mentioned reference 5). Like the amorphous magnetic substance, enough, in the case of the high chip of permeability, even if the coil is distant from the chip tip, it can reverse magnetization at a tip. However, in the case of the chip which carried out the coat of the magnetic film, a coil needs to approach at the tip of a chip enough, and it is necessary to form it in it. Moreover, although it is required that a probe should have predetermined die length when winding a coil around the perimeter of a chip, on the other hand, a chip becomes easy to detect vibration and this has it from a mechanical standpoint. [by no means desirable] This vibration has the fault of making delicate positioning difficult. In the magnetic recorder and reproducing device which is made to generate tunnel current and is going to attain high density record, this is a problem. It is the configuration which one configuration which solves these problems fixed the superficial flat coil to the medium front face, and shortened the probe. If the coil by RISOGURAFU can be formed on a medium, the manufacture effectiveness of a coil assembly improves considerably, the die length of a probe can be shortened and the problem in positioning of a chip can also be solved.
[0013]
[Problem(s) to be Solved by the Invention] The purpose of this invention is specifically in the thing with high-speed possible switching of the magnetization direction of a chip for which the equipment in which high-speed record playback of data is possible is offered by the component switchable to 10MHz order.
[0014] Furthermore, the purpose of this invention forms a coil by RISOGURAFU on a medium, and raises the manufacture effectiveness of a high density record regenerative apparatus, and it is shown in planning cost reduction.
[0015] Furthermore, the purpose of this invention is about data more at high density to offer the magnetic recorder and reproducing device in which magnetic recording is possible.
[0016]
[Means for Solving the Problem] In this invention, a chip is what covered the magnetic material of high permeability with the spatter to the non-magnetic material, and is constituted. Moreover, a coil is arranged on the perimeter at the tip of a chip, and switching of the magnetization direction at the tip of a chip is performed by this coil. This coil is in the condition of having insulated with the record medium.
[0017] The main configurations of this invention are a means generate tunnel current between the core which consists of a non-magnetic material, the chip which has the thin film which consists of the soft

magnetic materials which cover a core, a conductive magnetic-recording medium, and a chip and the above-mentioned magnetic-recording medium, a means control the above-mentioned tunnel current, a means measure the control voltage which controls the above-mentioned tunnel current, and a means reproduce the signal recorded on the above-mentioned magnetic-recording medium from the above-mentioned control change of potential.

[0018] Furthermore, it has the coil formed in the perimeter of a chip, and a means to impress the signal current to the above-mentioned coil, and the field generated according to this signal current from the above-mentioned chip by impressing the signal current to a coil performs signal record to the above-mentioned magnetic-recording medium.

[0019] The non-magnetic material which forms a core is Tungsten W, Platinum Pt, Iridium Ir, platiniridium PtIr, Gold Au, glass fiber, a carbon fiber, or such combination, the soft magnetic materials which cover a core are NiFe, CoZrNb, or CoFeSiB, and thickness is 500-3000A. Moreover, as a return path of magnetic flux, the configuration of the following reference (9) is available.

[0020] (9) O.Watanuki, "Magnetic Flux Return Path for High Density Vertical Recording", IBM TDB, Vol.32, No, 8A, pp.362-363, Jan.1990. [0021]

[Example] A chip is what covered the magnetic material of high permeability with the spatter, and is constituted by the core of a non-magnetic material. W, Pt, Ir, PtIr, Au, etc. are used as a non-magnetic material for cores. As a magnetic material, it is Fe. NiFe CoZrNb CoFeSiB etc. is used. The radius of curvature at the tip of a chip is usually 100nm order, and a magnetic material coat is 1000 to 2000 A desirably about 500 to 3000 A. In the switching speed test which the chip of a magnetic force microscope (MFM) (the above-mentioned reference 7) was made to approach a thin film head, and performed it, the switching rate of 50MHz was attained in W chip which covered Fe.

[0022] The outline block diagram of the magnetic recorder and reproducing device of this invention is shown in drawing 1 . A chip 11 approaches the magnetic-recording medium 12, and is constituted, and the coil 13 is constituted by RISOGURAFU on the magnetic-recording medium 12. A chip 11 is connected to the coarse control device 14 and a finetuner 15, and position control is made. The coarse control device 14 is a voice coil motor (VCM) or a micro mechanism. As for a finetuner, a piezo-electric element and PZT are used. In the example shown in drawing 1 , X and the direction of Y, i.e., a direction parallel to a magnetic-recording medium front face, are adjusted by the finetuner 15 connected to the chip, and a Z direction, i.e., a direction perpendicular to a magnetic-recording medium front face, is adjusted by Z piezo-electric element constituted by the medium lower part, and adjustment of the distance on a chip and the front face of a record medium is made. The piezo driver 17 is connected to Z piezo-electric element.

[0023] Like drawing 1 , a coil is constituted by RISOGURAFU on a medium. Switching of the magnetization direction at the tip of a chip is performed by this coil. This coil is constituted through the record-medium front face and the insulator layer 19, and a medium has it in the condition of having insulated. This insulator layer 19 is SiO2 and aluminum2O3 grade, and thickness is several microns or more.

[0024] The partial expanded sectional view of the contiguity part of a chip 11 and the magnetic-recording medium 12 is shown in drawing 2 . Position control is made by the coarse control device 14 and the finetuner 15 so that a chip 11 may approach the recordable part of the magnetic-recording medium 12. The coil 13 is formed in the perimeter of the record section of the magnetic-recording medium 12. A coil 13 is formed of RISOGURAFU on a magnetic-recording medium through an insulator layer 19. An insulator layer is not formed in an information record part. Moreover, the record medium has the 100-200A protective coat which consists of C etc. for antioxidizing. As for this medium layer, what has desirable two-layer perpendicular magnetic anisotropy films, and has moderate coercive force is good. For example, an about 1-micron NiFe layer is constituted on a substrate, and the thing in which CoCr which has the thickness of about several 100-1000A as the upper layer was formed is used. A medium is formed in the non texture substrate which has a smooth front face by approaches, such as a spatter.

[0025] Simulation of the field from a chip tip was performed with the boundary element method, having

used thickness of 1000 and a medium as 1000A for a chip and lower layer permeability. The result of this simulation is shown in drawing 3 . The graph on drawing 3 shows the physical relationship of each configuration member, and a lower graph shows the situation of the field generated corresponding to this physical relationship. A field with an upper horizontal curve is shown and a lower curve shows a vertical field. It is clear for actual record to be performed by the perpendicular field and to have very good magnetic influence. The perpendicular field is concentrated near a chip tip and, thereby, high density record is attained.

[0026] A chip is moved in X and the direction of Y by the positioning means of coarse control and fine control. As a coarse control positioning means, a voice coil motor (VCM) and a micro mechanism are used. A piezo-electric element PZT is used as a finetuner. A magnetic-recording medium is laid on Z-PZT, and maintains spacing of a chip and a magnetic-recording medium from ** to the order of nm. It is good also as a configuration which constitutes PZT of X, Y, and all Z directions in the tip side, and enables the three-dimension drive only of a chip.

[0027] Supposing a chip writes a 300nm magnetic dot, one bit cel can be made into a 500nm thing. It becomes the cel of 1cm, then 1cm2 with the storage capacity of 400M bit, i.e., 50 megabytes, about the stroke of the direction of a flat surface of a chip. It is possible to enlarge the stroke of a chip, of course and to also make storage capacity increase, and it is possible to also make the record section of a magnetic-recording medium increase as a drive being possible with a chip, without fixing a coil.

[0028]

[Effect of the Invention] According to this invention, the activation of data logging by formation of the magnetic pattern to a medium at a high speed will be attained by high-speed switching of a chip, and improvement in record speed can be aimed at. Furthermore, large simplification of the manufacture process is attained by the improved coil configuration.

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DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]
[Drawing 1] It is the block diagram showing the configuration of the high density record regenerative apparatus concerning this invention.
[Drawing 2] It is the partial expanded sectional view showing the relation of the chip of the high density record regenerative apparatus concerning this invention, a coil, and a medium.
[Drawing 3] It is drawing showing the result of having measured the field generated using the high density record regenerative apparatus concerning this invention with the boundary element method.
[Description of Notations]
11 Chip
12 Medium
13 Coil
14 Coarse Control Device
15 Finetuner
16 Power Source
17 Piezo Driver
18 Amplifier
19 Insulator Layer

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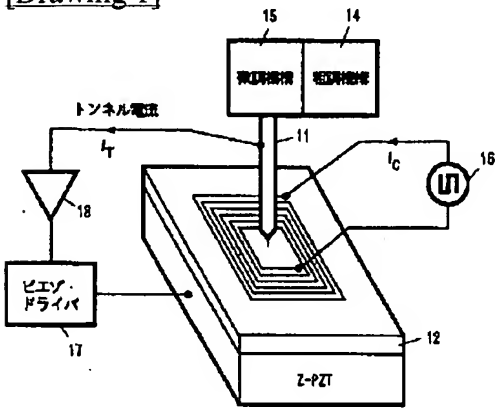
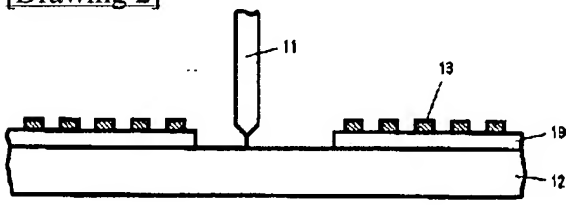
DRAWINGS

[Drawing 1]



[Drawing 2]



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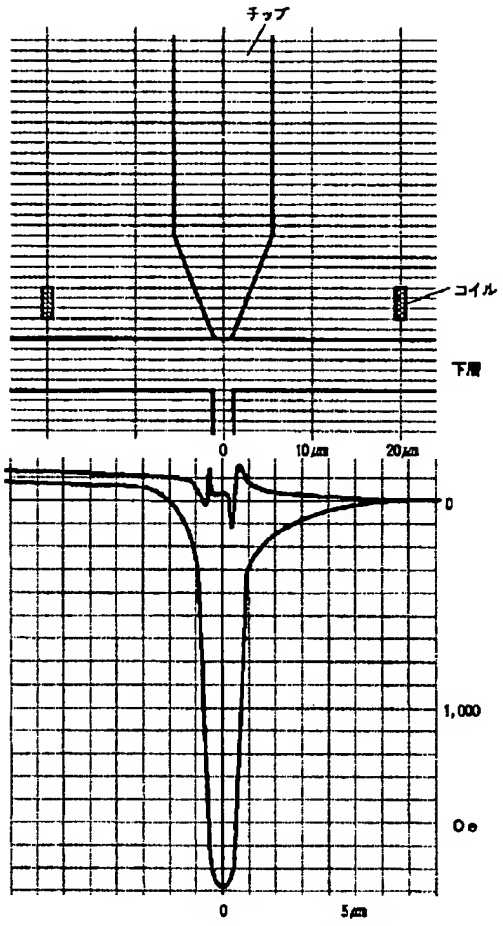

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